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(54) Three-phase voltage stiff convertor.

(57) A three-phase voltage stiff converter (SR) has two six-pulse converters (SR1, SR2). The alternating voltage terminals of the partial converters are connected to a transformer (TR) with the aid of which the resultant alternating voltage of the converter is formed as the difference between the alternating voltages of the partial converters. Each partial converter has a separate direct voltage source (C1, C2). The converter has control members (SD) which control the two partial converters with a mutual phase displacement alternating between +150° and -150°.

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The invention relates to a three-phase voltage stiff converter according to the precharacterising part of claim 1.

A voltage stiff converter is a self-commutated converter, the direct voltage of which, at least in the short run, is substantially constant. This can be achieved, for example, with the aid of a capacitor bank connected to the direct voltage terminals of the converter. Such a converter may be used for compensating reactive power in an a. c. network. The converter is then connected via a small inductance to the a. c. network, whereby this small inductance may consist of the leakage inductance of a transformer connected between the converter and the network. The reactive power flow between the converter and the network may be controlled by variation of the amplitude of the alternating voltage of the converter. Any active power flow between the converter and the network may be controlled by variation of the phase angle between the alternating voltages of the converter and the network.

To reduce unwanted effects on the network from the converter, it is desirable that the alternating voltage of the converter exhibits a good sinusoidal curve shape, that is, is relatively free from harmonics. One way to reduce the harmonic content of the alternating voltage is to carry out a so-called pulse width modulation of the converter. The large number of commutations per period in such a converter, however, gives rise to high losses, which makes such a converter less suitable at high power ratings.

Another way of obtaining an improved curve shape is to increase the pulse number of the converter, that is, the number of commutations per alternating voltage period. A three-phase converter with bridge-connected valves in its simplest form has the pulse number six. A considerable improvement of the curve shape may be obtained by doubling the pulse number of the converter. This can be obtained in a known manner by so-called twelve-pulse connections in which the voltages from two phase-shifted six-pulse converters are combined. There are two main types of twelve-pulse connections. In a first known connection of this kind, two separate transformers are required and therefore the equipment is complicated and expensive. In the second known converter connection of this kind, only one transformer is required; but this connection has the disadvantage that circulating currents will flow between the two six-pulse converters. Special measures in the form of increased leakage reactance of the transformer or in the form of separate inductors are required to limit these circulating currents, resulting in increased complication of the converter. Further, the circulating currents, which cannot be entirely eliminated, give rise to additional losses in the converters and require over-dimensioning thereof.

A further way of achieving an improved curve shape is using the so-called double six-pulse connection. In this case only one single transformer is used, with an open winding for connection to two six-pulse converters with a common direct voltage source. By an open winding is meant a winding in which both ends of each phase winding are accessible for external connections. Each phase winding has one of its ends connected to an alternating voltage terminal of one partial converter and its other end connected to the corresponding alternating voltage terminal of the other partial converter. The three phases at one end of this winding system may be considered to constitute a first three-phase system and the three phases at the other end of the winding system may be considered to constitute a second three-phase system. The difference between these two voltage systems constitutes the voltage system that is applied to the transformer. However, this known connection has the disadvantage that a zero-sequence voltage is applied to the transformer, which zero-sequence voltage will then be supplied to the alternating voltage network to which the converter plant is connected. This zero-sequence voltage may be limited by providing the converter plant with a zero-sequence inductor, which absorbs the zero-sequence voltage. However, such an inductor entails a considerable complication of the plant and renders it more expensive. According to another method, the transformer may be provided with an extra unwound leg, the transformer thus operating as a zero-sequence inductor. However, this entails a significant complication of the transformer. Further, in such a transformer the transformer winding, connected to the network, cannot be grounded at its star point, which means that the winding has to be fully insulated thus rendering the transformer even more expensive.

A so-called double six-pulse connection of one of the two types mentioned above is shown in Figure 1. The two six-pulse converters SRA and SRB are connected on their direct voltage sides to a common direct voltage source, which consists in the shown example of a capacitor bank C. The alternating voltage sides of the converters are connected, via a transformer TR and inductors LA, LB, LC, to a three-phase network N. The converters are controlled such that their alternating voltages are displaced in phase approximately 150°. The transformer has an extra unwound leg XL.

A double six-pulse connection of the second of the two types mentioned above is shown in Figure 2. It has a zero-sequence inductor LC with three phase windings on a common core.

A third known way of obtaining a twelve-pulse

function and hence an improved curve shape is by using a so-called NPC-type converter (NPC = Neutral Point Clamped). However, such a converter has a more complicated main circuit and comprises more semiconductor components than a traditional double six-pulse or twelve-pulse connection. Further, in such a converter certain of the semiconductor components are loaded more severely than the others, which for a certain given load requires an overdimensioning of the first-mentioned semiconductor components and hence makes the converter more expensive or reduces its maximum power rating.

In all of the known cases mentioned above, thus, a reduction of the harmonics is obtained at the expense of increased losses and/or considerable complications of either the transformer or the converter.

The invention aims at developing a three-phase voltage stiff converter of the above-mentioned kind, in which

- simple six-pulse bridges may be used,
- a conventional, simple three-limb transformer may be used,
- the star point of the network winding of the transformer may be grounded, thus reducing the demands for insulation of the transformer, and
- a good curve shape may be obtained with low commutating frequencies and hence low converter losses.

To achieve this aim the invention suggests a three-phase voltage stiff converter according to the introductory part of claim 1, which is characterized by the features of the characterizing part of claim 1.

Further developments of the invention are characterized by the features of the additional claims.

By way of example, the invention will now be described in greater detail with reference to the accompanying drawings showing in

Figures 1 and 2
two prior art so-called double six-pulse connections,

Figure 3
an embodiment of a converter according to the invention for reactive power compensation in an alternating voltage network,

Figure 4
schematically the configuration of the main circuit of one of the two partial converters in Figure 3,

Figures 5a and 5b,
in the form of block diagrams, the configuration of the control system for the converter according to Figure 3,

Figures 6 and 7,
in connection with two alternative control methods, the curve shapes of some of the electrical quantities occurring in the converter according to Figure 3,

Figure 8
how the control system shown in Figure 5a and 5b may be modified to provide the function shown in Figure 7,

Figure 9
schematically how a converter according to the invention may alternatively be used to equalize peak loads in an alternating voltage network by energy storage.

Figure 3 shows a converter SR according to the invention, which via inductors LA, LB, LC is connected to a three-phase alternating voltage power network N. The converter is intended to be used for reactive power compensation of the network, whereby is meant that the converter may generate or consume a variable reactive power, for example for increasing the power factor of the network or for controlling the voltage of the network. The inductors just mentioned lie in series with the leakage reactances of the converter transformers and may be omitted if said leakage reactances are sufficiently large. The converter comprises two self-commutated voltage stiff converters SR1 and SR2, which consist of six-pulse bridges, a transformer TR and a control device SD. Each partial converter has alternating voltage terminals a1, b1, c1 and a2, b2, c2, respectively. To the direct voltage terminals D1u and D1n of the partial converter SR1, a first capacitor bank C1 is connected, and to the direct voltage terminals D2u and D2n of the partial converter SR2, a second capacitor bank C2 is connected. In a manner which will be described below the capacitors C1 and C2 are maintained charged to a suitable voltage and constitute separate and galvanically separate direct voltage sources, one for each partial converter. The transformer TR has on the converter side an open three-phase winding AS, BS and CS and on the network side a star-connected three-phase winding AN, BN and CN. The transformer has a terminal GC, connected to the star point of the network winding, for grounding of the network winding. The network winding further has connections A, B, C for connection to the network N. Each one of the three phase windings AS, BS, CS is connected, with one of its ends, to an alternating voltage terminal in one of the partial converters and, with its other end, to the corresponding alternating voltage terminal in the other partial converter.

The converter has a control system SD for control of the function of the converter. In Figure 3 only the control pulse devices SD1 and SD2 are shown, which deliver control pulses sa1, sb1, sc1 to the partial converter SR1 and sa2, sb2, sc2 to the partial converter SR2.

Figure 4 shows the configuration of the partial converter SR1. The partial converter SR2 is built up in identically the same way. Each phase of the partial converter has two series-connected semiconductor valves, for example Tau and Tan. As shown in Figure 4, these may be built up as turn-off thyristors (so-called GTO thyristors). Alternatively, the valves may be built up of non-turn-off thyristors, which are then provided with quenching circuits, or possibly of transistors or other controllable valves. Each valve may consist of a plurality of series-connected semiconductor elements. In antiparallel with each valve, a bypass diode, for example Dau, Dan, is arranged. The diode may be integrated with the controllable semiconductor element. The point of connection of the valves and the diodes is connected to the alternating voltage terminal a1 of the converter. The other two phases are built up in the same way. The two valves in the same phase are controlled such that one valve is always conducting and the other valve is non-conducting. The three phases are controlled with a mutual phase displacement of 120°, a three-phase voltage system thus being generated on the alternating voltage terminal a1, b1, c1 of the converter.

Each partial converter generates a six-pulse three-phase voltage system. The difference voltage between these two systems is applied across the converter winding of the transformer. If the partial converters lie in phase, the difference voltage and hence the transformer voltage will be zero. If the partial converters are controlled such that they operate with a 180° phase displacement, a six-pulse voltage with an amplitude twice as large as the voltage of each partial converter is applied across the transformer. However, according to the invention, the partial converters are controlled such that their phase displacement is +150° or -150°, whereby a twelve-pulse voltage with a low harmonic content occurs across the transformer.

The above-mentioned phase displacement between the two partial converters means that at least one of the partial converters must operate with a phase displacement relative to the network which deviates from the values of the phase displacement, 0° and 180°, at which the flow of active power between the network and the partial converter is zero. This means that the capacitor bank of at least one of the converters will be continuously charged or discharged, which would make steady-state operation impossible. In the converter according to the invention, this problem is solved by constantly reversing the sign of the phase displacement between the partial converters during operation.

Figure 5a shows the control system for the converter according to Figure 3. Each partial converter has a control pulse device, SD1 and SD2, respectively, which in a known manner deliver control pulses to the converters. The line voltage is sensed with the aid of a voltage measuring device UAM, for example a voltage transformer, and is supplied to a synchronizing device SY which delivers a synchronizing signal ϕn which is a measure of the phase position of the line voltage and which, in the absence of additional control signals from the control system, keeps the two control pulse devices in such phase positions relative to the line voltage that, for one thing, the partial converters operate in opposition and, for another, the alternating voltage of the converter (the difference between the voltages of the two partial converters) lies in phase with the a. c. voltage of the network.

The voltage "un" from the voltage measuring device UAM is supplied to a reactive power forming member QM. To this member is also fed a signal "in" which corresponds to the converter current and which is obtained with the aid of a current measuring device IM arranged between the converter and the network. The reactive power forming member QM forms a signal Q which is proportional to the reactive power flowing between the converter and the network and which is supplied to a summator SM1. To this summator is also fed a reference value Qr for the reactive power which is obtained with the aid of a reference value transducer QP. The difference between the signals QR and Q is supplied to a reactive power regulator QR with PI-characteristic. The output signal uDr from the regulator constitutes a reference value for the direct voltage of the two capacitors C1 and C2. The capacitor voltages are sensed with the aid of voltage measuring devices UDM1 and UDM2 and are supplied to summators SM2 and SM3, where they are compared with the reference value uDr. The difference signals obtained with the aid of the summators are supplied to direct voltage regulators UDR1 and UDR2 with P-characteristic. The output signals $\phi 10$ and $\phi 20$ of the regulators are supplied to summators SM4 and SM5, the output signals $\phi 1$ and $\phi 2$ of which are supplied to the two control pulse devices SD1 and SD2. When the signals $\phi 1$ and $\phi 2$ are zero, the two partial converters operate in opposition, that is, each commutation in one partial converter is 180° phase displaced in relation to the corresponding commutation in the other partial converter. Further, within each partial converter, in this case, the three phases are mutually phase-displaced by 120° and the two valves in the same phase operate at 180° mutual phase displacement. Further, the phase position is such that the resultant alternating voltage of each converter lies in phase with the alternating line voltage, and therefore no active power flows between the network and the converters. Since the converters lie in

opposition, the resultant alternating voltage, as mentioned above, is a six-pulse voltage, that is, a voltage with a relatively high harmonic content.

A positive value of the signal $\phi 1$ or $\phi 2$ is phase-advanced relative to (appears prior to) the control pulses from the corresponding control pulse devices and hence to the commutations in and the alternating voltage from the corresponding partial converter. In a corresponding way, a negative value of the signal $\phi 1$ or $\phi 2$ is phase-retarded relative to (trails behind) the control pulses from the corresponding control pulse device.

A quantity ϕdiff, which corresponds to a phase displacement of 15°, is supplied to a switchable sign reverser SA. The output signal from this is supplied to the summator SM4 with a positive sign and to the summator SM5 with a negative sign. If the output signal from the sign reverser is positive, the commutations in the converter SR1 are thus phase-advanced by 15°, and the commutations in the converter SR2 are phase-retarded by 15°. The opposite is the case if the output signal of the sign reverser has a negative sign. The control pulses from the control pulse devices SD1 and SD2 are supplied to a logical network LN, which delivers an output pulse when the output signals of the two partial converters constitute the inverses of one another. The output pulses from the network LN are supplied to the sign reverser SA, which is changed over at each output pulse from the network LN.

The logical network LN in Figure 5a is built up in the manner shown in Figure 5b. It comprises three exclusive OR-gates OG1, OG2, OG3 and an AND-gate AG. Each OR-gate delivers an output signal if its two input signals are mutually different. Each positive flank of the output signal from the AND-gate AG switches the sign reverser SA. If the control signals sa1 and sa2 are different, an output signal is obtained from the gate OG1, if sb1 and sb2 are different an output signal is obtained from OG2, and if sc1 and sc2 are different an output signal is obtained from OG3. A control vector for the partial converter SR1 is defined by the quantities sa1, sb1, sc1, and a control vector for the converter SR2 is defined by the quantities sa2, sb2, sc2. One of the control vectors is the inverse of the other if sa1 ≠ sa2 and sb1 ≠ sb2 and sc1 ≠ sc2, and when this is the case, output signals are obtained from all three OR-gates and an output signal is obtained from the AND-gate AG to the sign reverser to bring about a sign reversal.

In steady state, the reactive power Q corresponds to the desired one (Qr). The output signal from the reactive power regulator QR is therefore constant and equal to that value of the capacitor voltages which provides the desired reactive power. Further, the two capacitor voltages are equal to the reference value uDr obtained from the reactive power regulator, and the signals $\phi 10$ and $\phi 20$ are both zero. At a certain instant the output signal from the sign reverser SA is positive. The next commutation will therefore be phaseadvanced by 15° in the converter SR1 and phase-retarded by 15° in the converter SR2, that is, the commutations will take place with a 30° phase displacement. During this commutation the sign reverser is changed over, and $\phi 1$ and $\phi 2$ change signs. The next commutation will therefore be phase-retarded by 15° in the converter SR1 and phase-advanced by 15° in the converter SR2. In this way the two partial converters will operate with a mutual phase displacement which is alternately +150° and -150°. A commutation will take place in one of the partial converters each 30° and the resultant alternating voltage of the converter becomes a twelve-pulse voltage with a low harmonic content. Each partial converter will alternately be 15° phase-advanced and 15° phase-retarded, respectively, in relation to that phase position in which the active power flow is zero. This means that power will alternately flow out of the capacitor of the partial converter and into the same capacitor. With the control principle now described, however, the mean value of this current will be zero, that is, the capacitor charge is constant.

The six uppermost curves in Figure 6 show the control pulses to the partial converters. When a control pulse is "1", the upper valve in the corresponding phase is conducting, and when a control pulse is "0", the lower valve in the corresponding phase is conducting. Below this, in Figure 6, the phase voltages ua1 and ua2 of the two partial converters are shown as an example. Below this, the resultant alternating voltage belonging to the phase A is shown, which alternating voltage constitutes the difference between the voltages ua1 and ua2. At the bottom in Figure 6, the two currents in iD1 and iD2 flowing to the capacitor banks are shown.

By influencing the phase position of the control pulses to the converter SR1 and hence the flow of active power and the capacitor current iD1, the closed control circuit formed from the units UDM1, SM2, UDR1, SD1 and SR1 will continuously maintain the voltage of the capacitor C1 equal to the reference value uDr. In a corresponding way, the voltage of the capacitor C2 will be maintained equal to the same reference value. The superordinate circuit for control of the reactive power comprises the units QM, QP, SM1 and QR. Thus, for example, an increase of the reference value QR will give rise to an increase of the voltage reference uDr and hence - in the manner described above - an increase of the capacitor voltages and hence of the total output voltage amplitude of the converter

until the flow of reactive power Q from the converter corresponds to the reference value QR.

The influence on the control of the partial converters exerted by the above-mentioned control circuits is preferably small and does not affect the previously described fundamental mode of operation of the converter.

In the above-described embodiment of the invention, as will be clear from Figure 6, the conduction intervals for the upper semiconductor valve in each phase are shorter than the conduction intervals for the lower valve in the same phase. The latter valve will therefore be subjected to a stronger thermal load, which reduces the maximum power of the converter. The starting state of the sign reverser SA decides which of the valves will have the longer and the shorter conduction interval, respectively, that is, in which of two possible modes the system will be operating.

In one embodiment of the invention, a change of the mode in which the converters are operating is periodically performed. This can be carried out by a control of the converters in accordance with the diagrams in Figure 7. Briefly, the control strategy means that one of the recurrent sign changes in SA is cancelled. In Figure 7 the system operates in a first mode prior to t = t1. At t = t1, a mode change is initiated, which is completed at t = t2, whereafter the system operates in its second mode.

By periodically changing the operating mode in this way, each individual converter valve will alternately belong to the valve group which operates with long conduction intervals and to that which operates with short conduction intervals. If the period for the change of mode thus carried out is short or comparable with the thermal time constant of the valve, the temperature increase caused by the losses will be equally great in all the valves of the converter. These may then be utilized in an economically optimum way. The change of mode may take place as often as upon every other commutation, that is, the sign reversal sequence will the be + + – + + – + + – ....

Figure 8 shows a device for carrying out the change of mode in the manner described above. The device comprises an extra sign reverser SB in the form of a multiplier, which reverses the sign of the output signal from the sign reverser SA (cf. Figure 5b). The multiplier is controlled by the output signal from a bistable circuit BC. This has a preparatory D-input which is connected to an oscillator OSC which provides a square wave with a lower frequency than the commutating frequency of the converter. Upon that commutation which follows immediately after each change of state of the output signal of the oscillator, the output signal of the circuit BC will change its sign, which means that the system changes the working mode.

Instead of being controlled by the free-swinging oscillator shown in Figure 8, the mode change may be controlled in some other way, for example in dependence on some measured system quantity, for example the temperature of the semiconductor elements.

Figure 9 shows an alternative application of a converter according to the invention. The direct voltage sources of the two partial converters here consist of accumulator batteries B1 and B2. At low load in the network N, the converter is controlled such that active power flows from the network into the accumulator batteries where it is stored. At high load, the converter is controlled such that active power flows from the batteries into the network. In this way, the load demand on the network's power generating sources may be equalized in a manner known per se. The control and function of the converter may, in principle, be the same as has been described above with reference to Figures 3 to 8; however, the control circuits for control of the individual capacitor voltages of course being replaced by control circuits which control the current through each of the accumulator batteries. The individual control then ensures that the mean current through each battery becomes equal to the common reference obtained from the superordinate control. In the same way, the control circuit shown in Figure 5 is suitably supplemented by members for control of the active power flow by common phase advance and phase retardation, respectively, of the two partial converters.

The embodiments and their applications described above are only examples and both other embodiments and other fields of application are feasible within the scope of the invention. Thus, the principle of the invention is described for six-pulse converters, the output voltages of which are combined so as to obtain a twelve-pulse voltage; but the principle according to the invention may be used also for other pulse numbers than those mentioned above. The above-described value of the signal ϕdiff, which gives a mutual phase displacement of 150° between the two partial converters, gives the lowest harmonic content, but also other values of the phase displacement between the two partial converters may be used. In a manner known per se, in a converter according to the invention one or more extra commutations may be performed every half-period to further reduce the harmonic content of the output voltage. The control methods described above are only examples.

A further reduction of the harmonic content of the generated a.c. voltage can be obtained by arranging two converters according to the invention in a multi-pulse connection. Each converter may be of the type described above in connection with

Figures 3 to 8. The transformer of a first one of the two converters has its network winding D-connected. The second one of the converters has a transformer, the network winding of which is an open winding, with each phase winding being connected between a terminal of the D-connected network winding of the first converter and the a.c. line. In this case, each converter works with a phase difference (ϕdiff) of 15°. The two converters operate with a mutual phase difference of 30°. The resulting a.c. voltage generated by this arrangement is close to an ideal 24-pulse voltage.

As will be clear from the foregoing description, according to the invention a converter is obtained which is capable of operating at a low commutating frequency and hence with low losses, while generating an alternating voltage with a low harmonic content. No zero-sequence voltages or circulating currents arise and therefore no special inductors or special transformer embodiments are required to eliminate such problems. Both the main circuits of the partial converters and the transformer have a configuration which is as simple and economical as possible. Therefore, a converter according to the invention is simple and economically favourable.

Claims

1. Three-phase voltage stiff converter (SR) comprising a first (SR1) and a second (SR2) partial converter preferably of the six-pulse type, each partial converter having alternating voltage terminals (a1, b1, c1; a2, b2, c2) and direct voltage terminals (D1u, D1n; D2u, D2n), in which the partial converters operate phase-displaced in relation to each other, in which the alternating voltage terminals of the partial converters are connected to a transformer (TR) for forming the alternating voltage of the converter by combination of the alternating voltages of the two partial converters, and in which the direct voltage terminals of each partial converter are connected to a direct voltage source, **characterized** in that the converter has two separate direct voltage sources (C1, C2), each one connected to the direct voltage terminals of one of the partial converters, and that the converter is provided with control members (SD) adapted to control the partial converters such that the phase displacement (ϕdiff) between the two partial converters constantly alternates between positive and negative values.

2. Converter according to claim 1, **characterized** in that the control members (SD) are adapted to control the partial converters such that the mean value of the phase displacement (ϕdiff) between them is zero.

3. Converter according to claim 1 or 2, **characterized** in that the control members are adapted to control the partial converters such that the phase displacement (ϕdiff) between them alternates between a positive value and an equally great negative value.

4. Converter according to any of the preceding claims, **characterized** in that the partial converters are six-pulse converters and that the control members are adapted to control the partial converters such that the phase displacement (ϕdiff) between them alternates between two values which are substantially equal to +150° and -150°.

5. Converter according to any of the preceding claims, **characterized** in that the control members are adapted to control the partial converters such that the phase displacement (ϕdiff) between them periodically alternates between said two values.

6. Converter according to claim 5, **characterized** in that the control members are adapted to control the partial converters such that the phase displacement between them changes sign each time the control vector in one of the partial converters is the inverse of the control vector in the other partial converter.

7. Converter according to claim 6, **characterized** in that the control members comprise members (OSC, BC) for suppressing occasional sign reversals for achieving a change of the operating mode of the converter.

8. Converter according to claim 7, **characterized** in that the control members comprise members (OSC) for suppressing occasional sign reversals with a frequency which is lower than the commutating frequency of each partial converter.

9. Converter according to any of the preceding claims for connection to an alternating voltage network and for delivering positive or negative reactive power to the network, **characterized** in that the direct voltage sources consist of capacitor banks (C1, C2).

10. Converter according to claim 9, **characterized** in that it is provided with members for control of the capacitor voltages (uD1, uD2) in dependence on the flow of reactive power (Q) between the converter and the network by in-

fluencing the phase position of the partial converters relative to the line voltage.

11. Converter according to any of the preceding claims, **characterized** in that the transformer (TR) has an open converter winding with three phase windings (AS, BS, CS), each phase winding having one of its end points connected to an alternating voltage terminal (e. g. a1) of one of the partial converters (SR1) and its other end point connected to the corresponding alternating voltage terminal (a2) of the other partial converter (SR2).

12. Converter according to claim 11, **characterized** in that the transformer (TR) has a star-connected network winding (AN, BN, CN) with a terminal (GC) for grounding the winding.

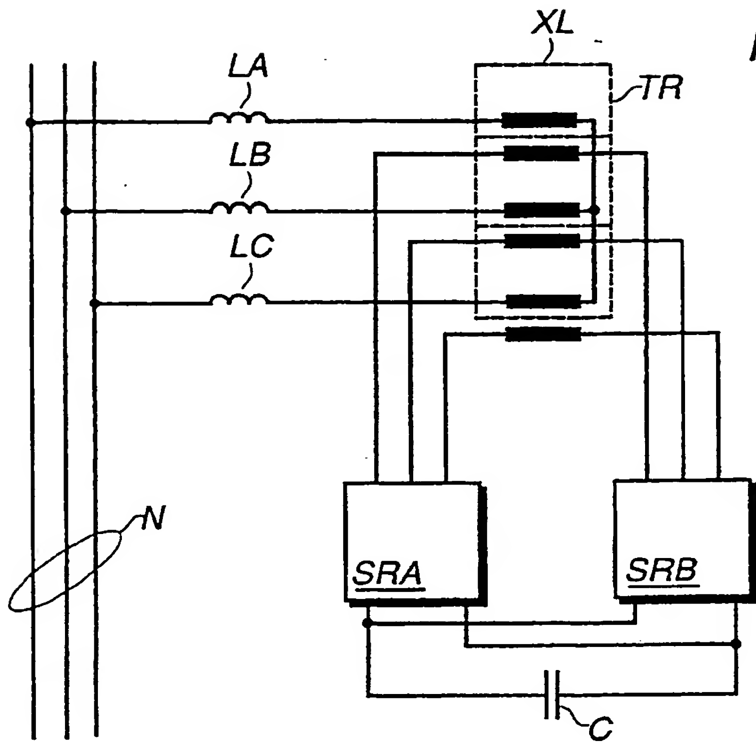

Fig. 1

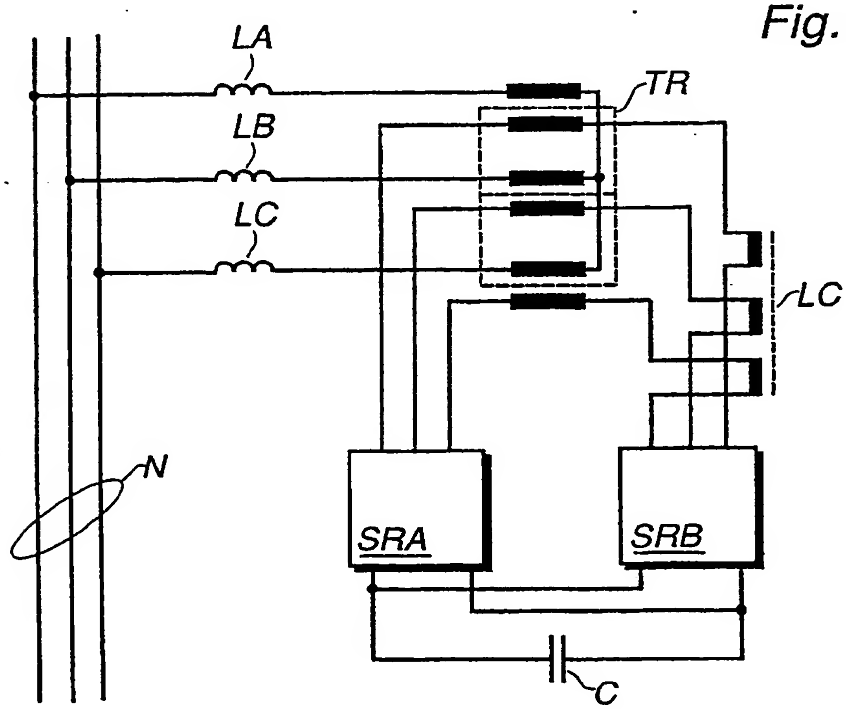

Fig. 2

Fig. 3

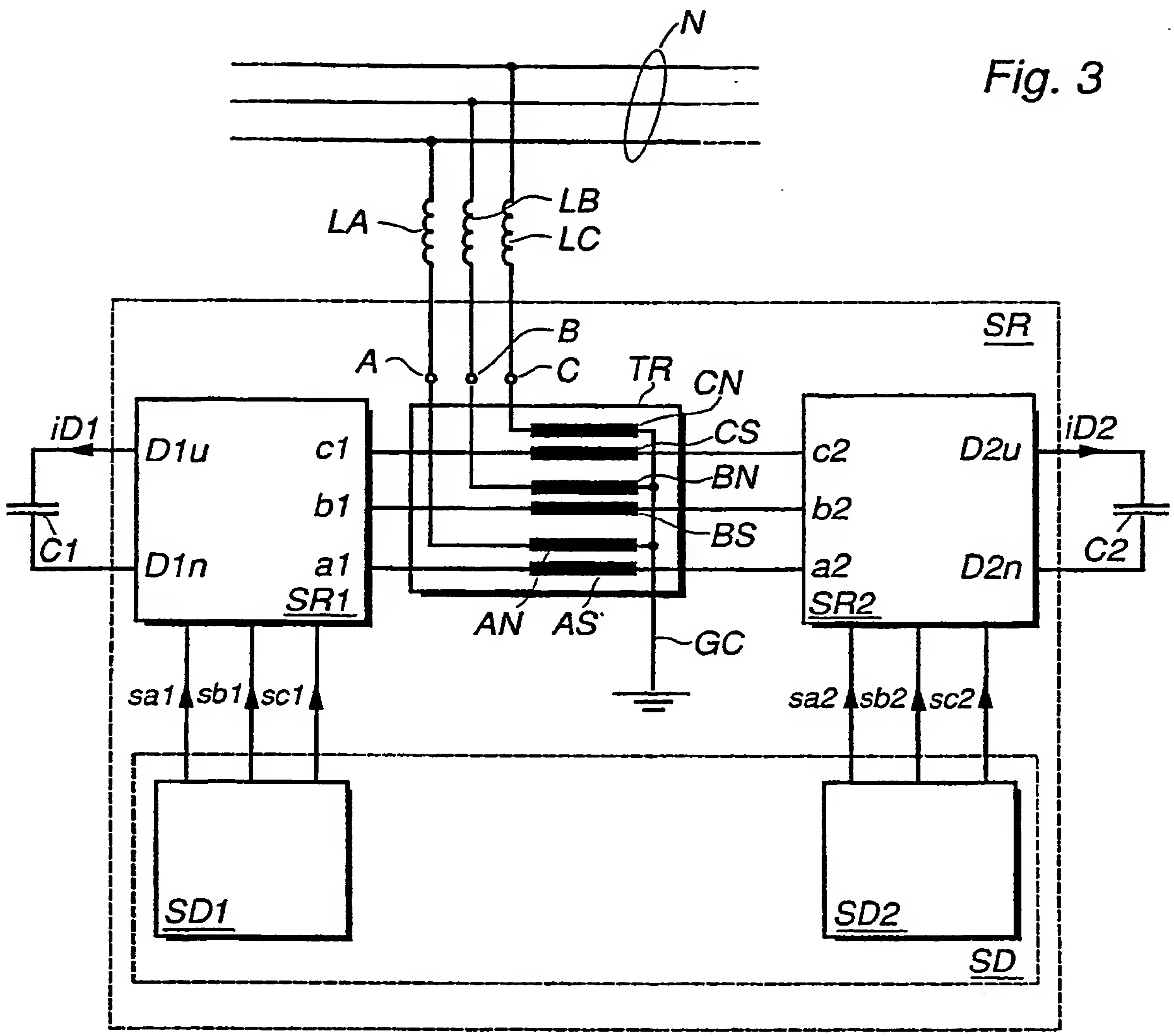
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Fig. 4

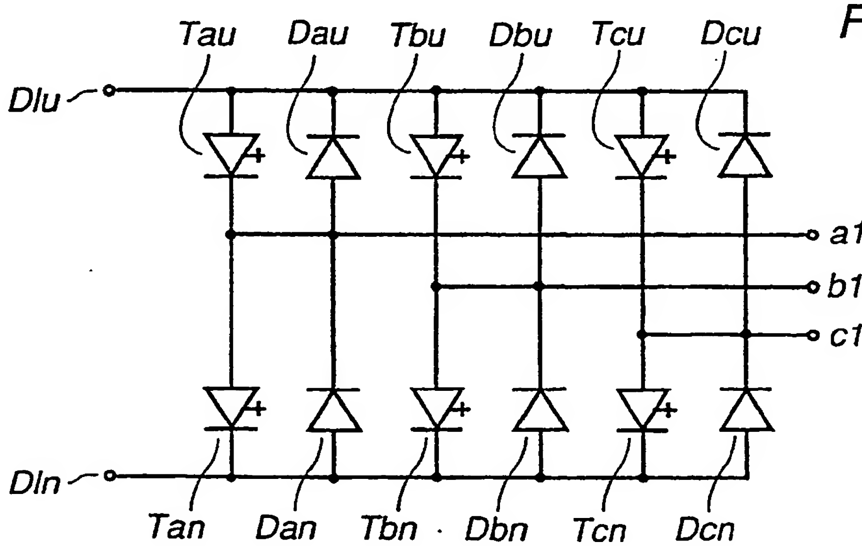
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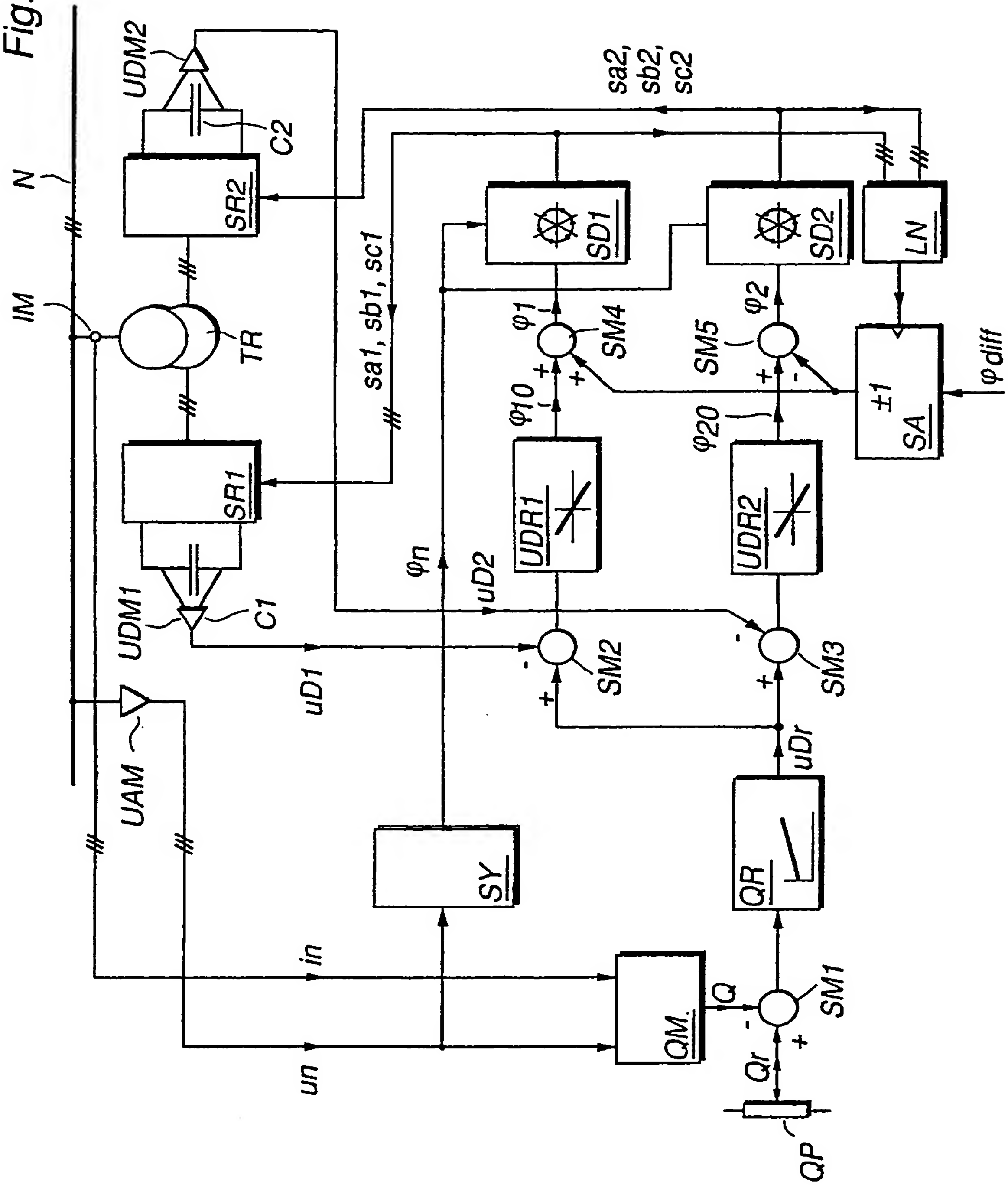
Fig. 5a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φ2
φ10
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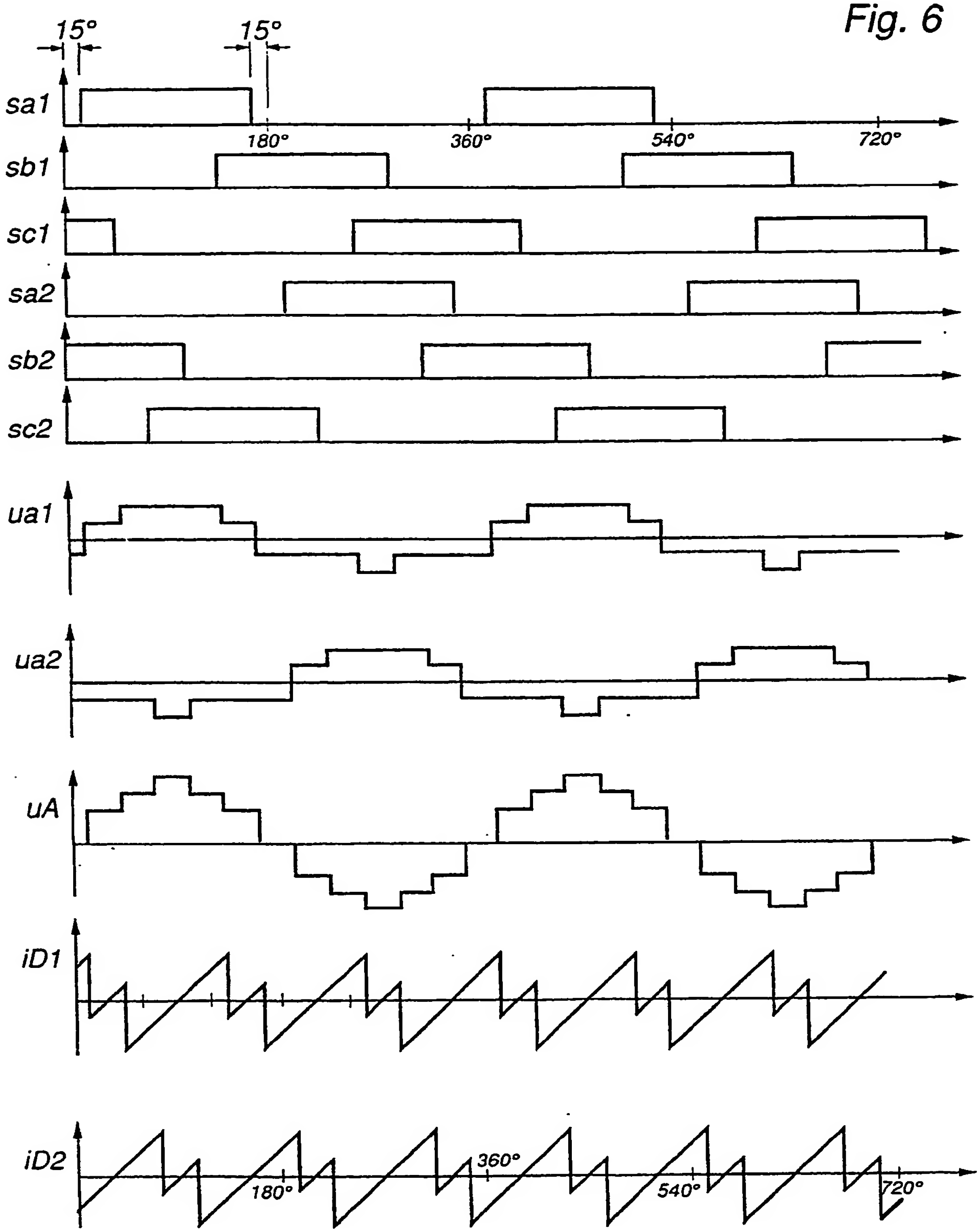
Fig. 6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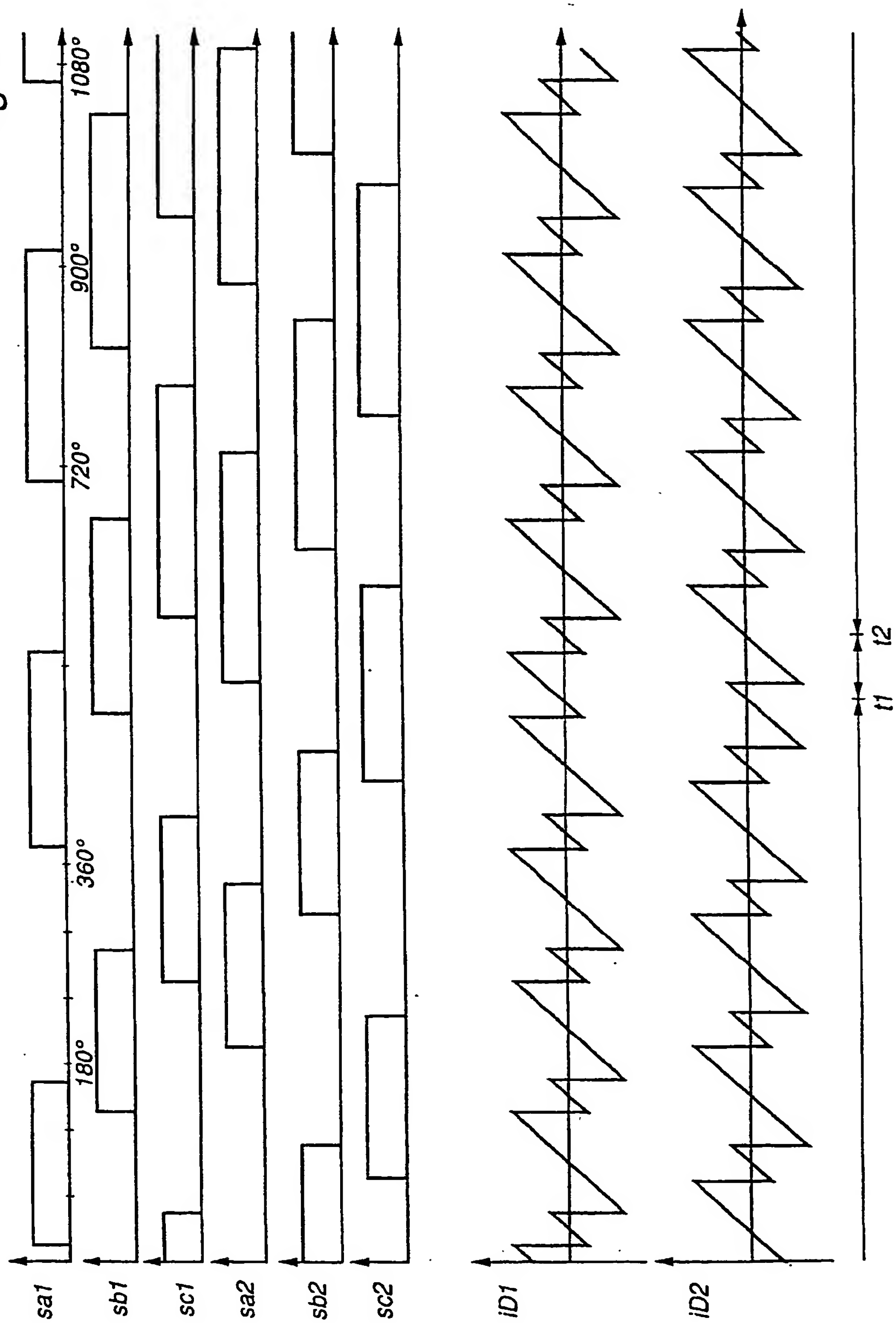
15°
sa1
180°
360°
540°
720°
sb1
sc1
sa2
sb2
sc2
ua1
ua2
uA
iD1
iD2
360°
180°
540°
720°

Fig. 7



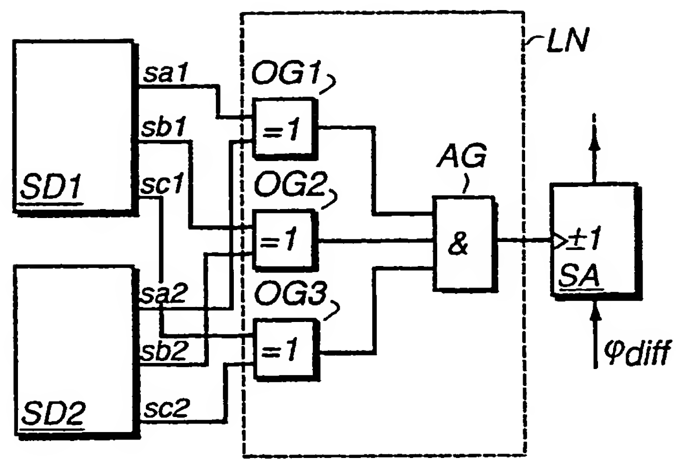


Fig. 5b

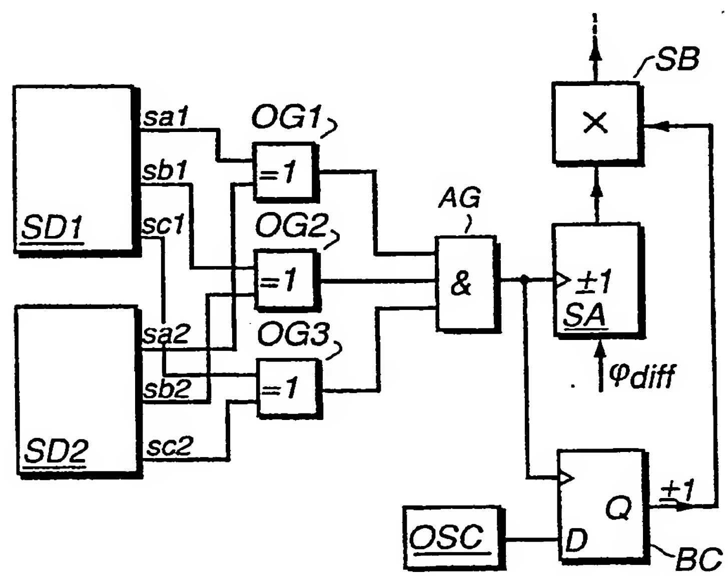


Fig. 8

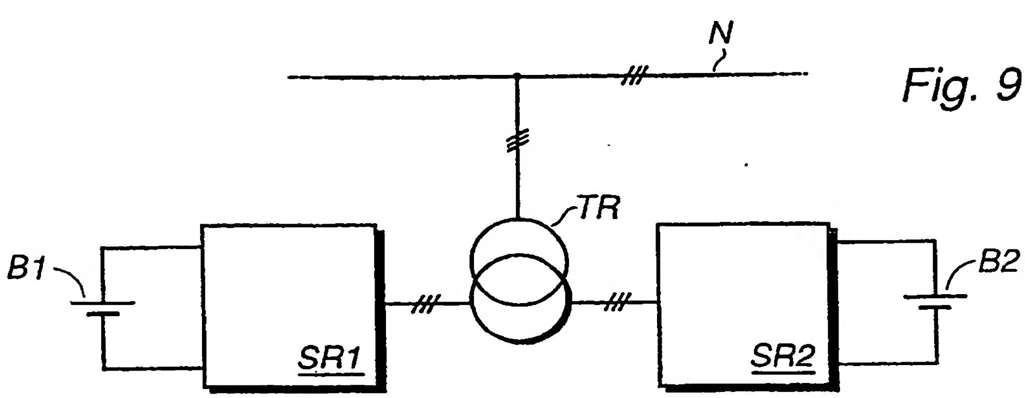


Fig. 9

European Patent Office

EUROPEAN SEARCH REPORT

Application number
EP 90125813.7

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-3 671 846 (COREY) *Column 1 line 67 - column 5 line 17* ---	1-12	H 02 J 3/18 H 02 M 7/77
A	Derwent's abstract no. 88-241808/34, SU 1372-467 (SAPO) ---	1-12	
A	DE-A-1 513 913 (LICENTIA PATENT-VERWALTUNGS-GMBH) *Page 3 line 12-19* ---	1-12	
A	US-A-4 063 143 (FORSTBAUER) *Column 2 line 31 - column 4 line 48* --- -------	1-12	
			TECHNICAL FIELDS SEARCHED (Int Cl.5)
			H 02 J H 02 M

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
STOCKHOLM	30-04-1991	SANDH H.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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